Processes Controlling Spatial Snow Distribution Variability at the Macro-Scale Level in Cold Regions

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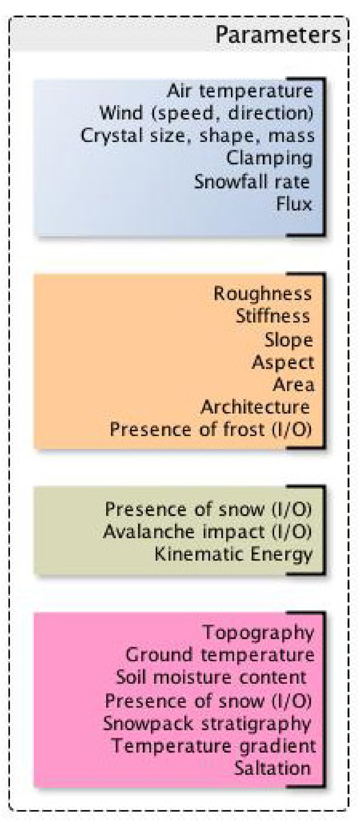
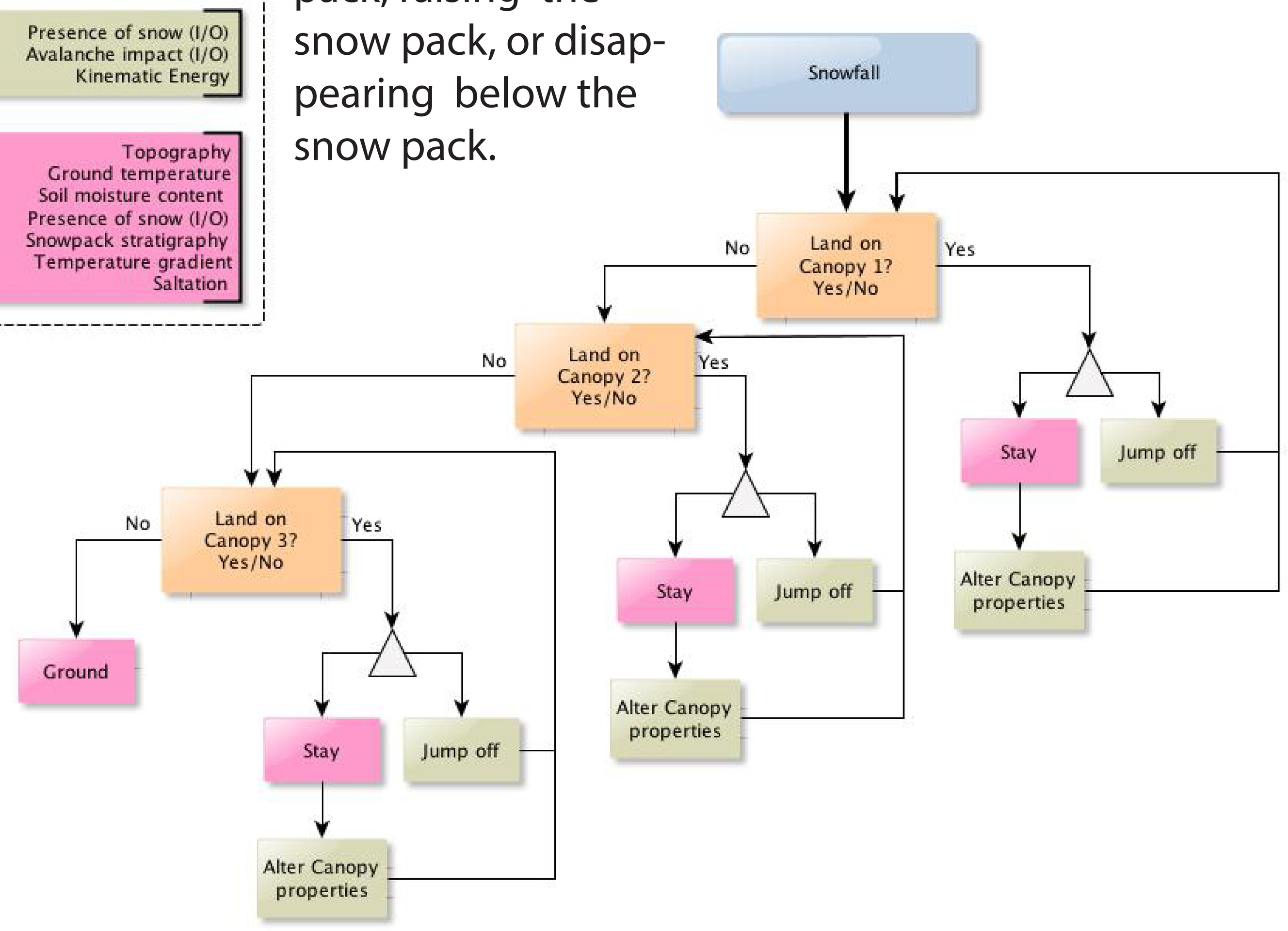
Abstract:
Spatial snow distribution is a result of interactions between snow flakes and other factors such as vegetation, wind , topography. The accumualtion of snow can be seen as a surface evolving snowfall after snowfall. The resulting snow depth distribution is the difference of the upper and lower surface of the snow. The lower interface of the snowpack changes winter to winter, but is fairly stable throughout a given winter. On the other hand, the upper surface's morphology is incrementaly evolving under external forces. Through three experiments, where external forces are isolated from each other, we attempt at understanding how they - vegetation, wind, and topography - interact with the snow pack, and ultimately control snow distribution.

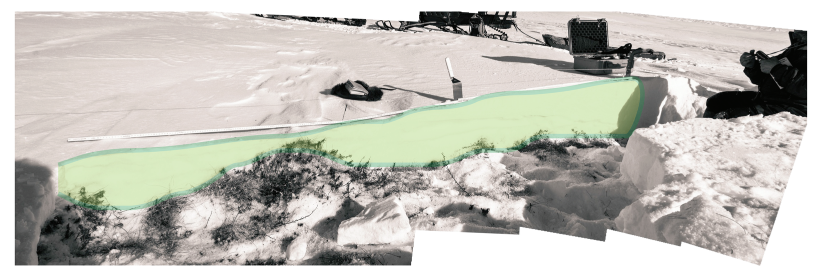
Vegetation Interception

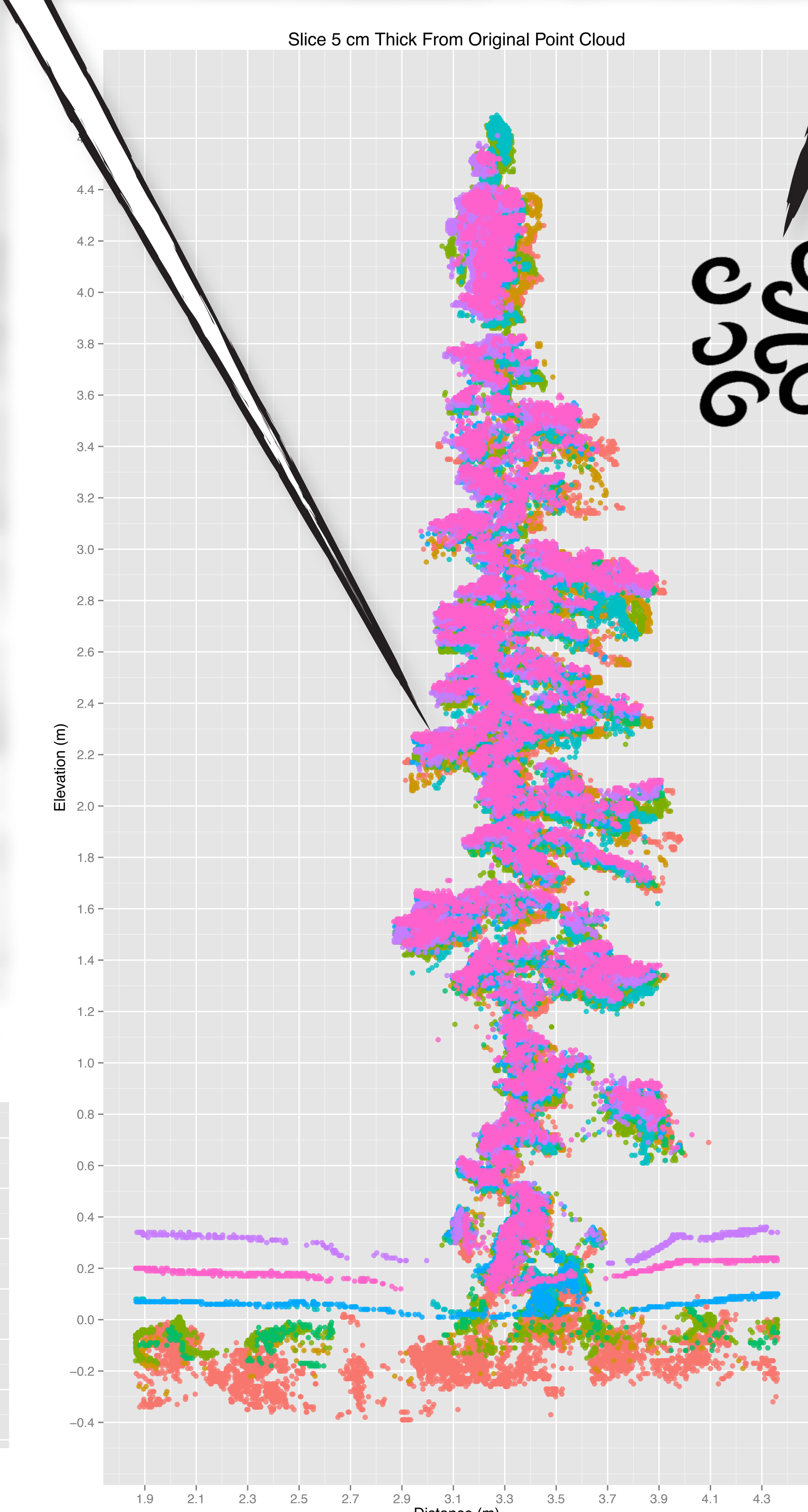
In forested area, vegetation plays an important role in redistributing snow. While falling, branches intercept snow flakes. The succesive level of canopy levels combined with plant mechanical properties, snow properties, surface leaf properties, frequency of wind events, and air sublimation potential, will drive the total branch loading. Three scenarios for plants are then possible: forming a depression in the snow pack, raising the snow pack, or disappearing below the snow pack.





Snowpit in the wind-blown snow of the North Slope

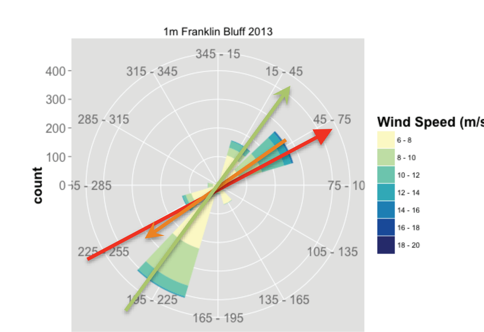




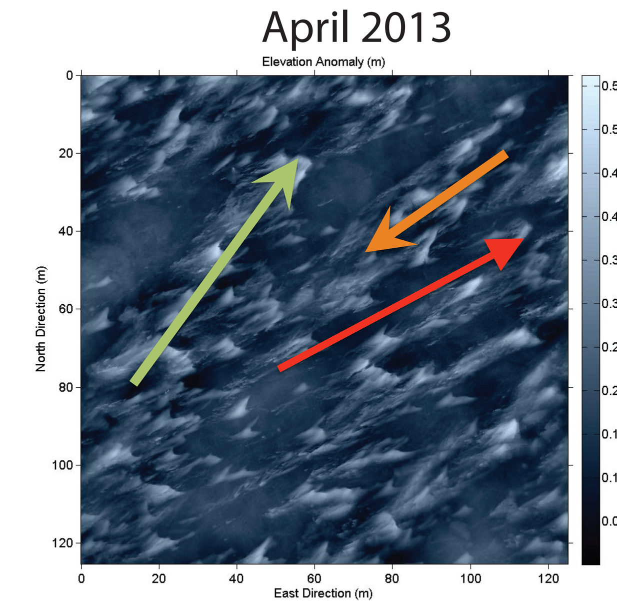
Wind / eolian processes

Not only wind greatly affects interception of snow by plants, but it mainly redistibutes snow horizontally, lifting and then carrying particles from the surface in wide open landscapes. During this process, periodic and characteristic features appear at the snow surface. They can be the result of local snow accumulation (i.e. dunes), or local eolian erosion like sastrugi. The outcome is a surface varying depending on the sequence of events of snowfalls and wind. The underlying micro-topography also shows some influence on the resulting carved relief.

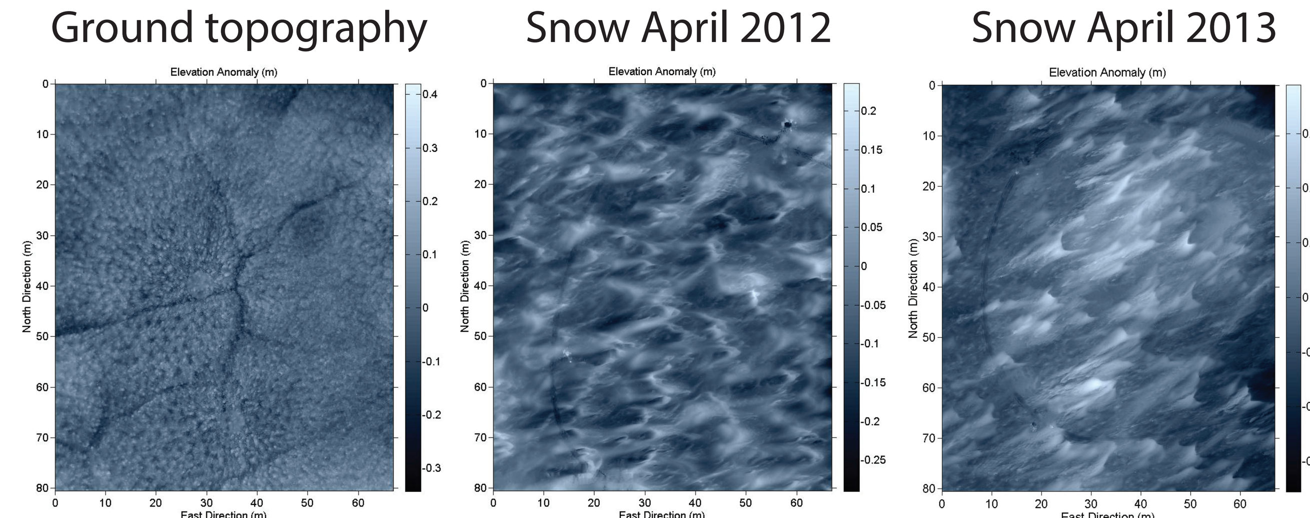
Wind rose 2012-2013

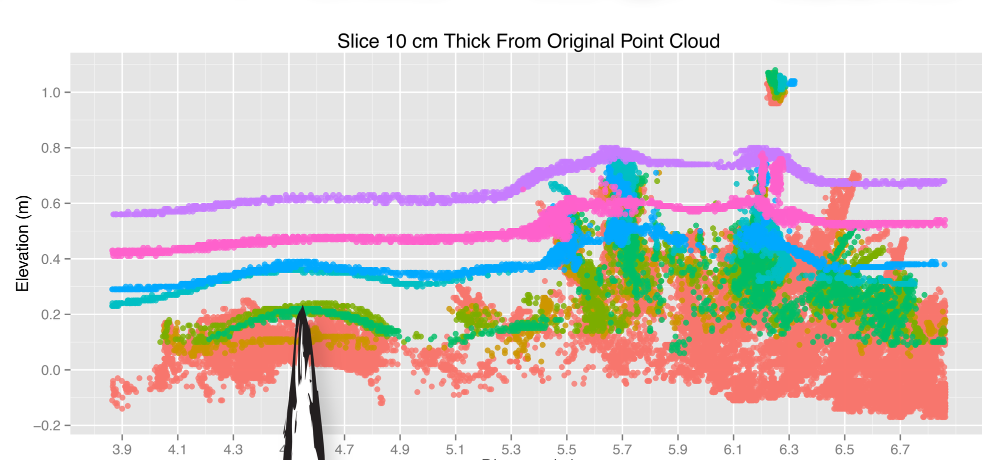


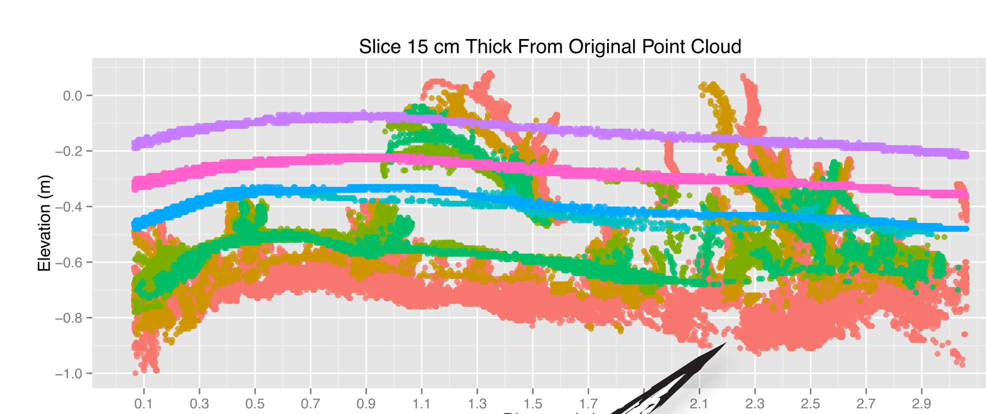
Snow surface on lake ice April 2013



Ground topography Snow April 2012 Snow April 2013

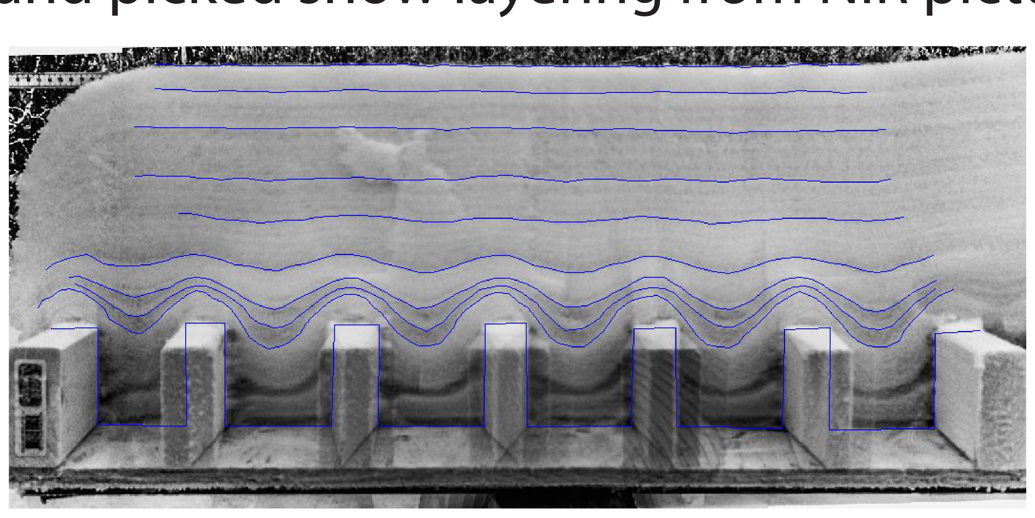




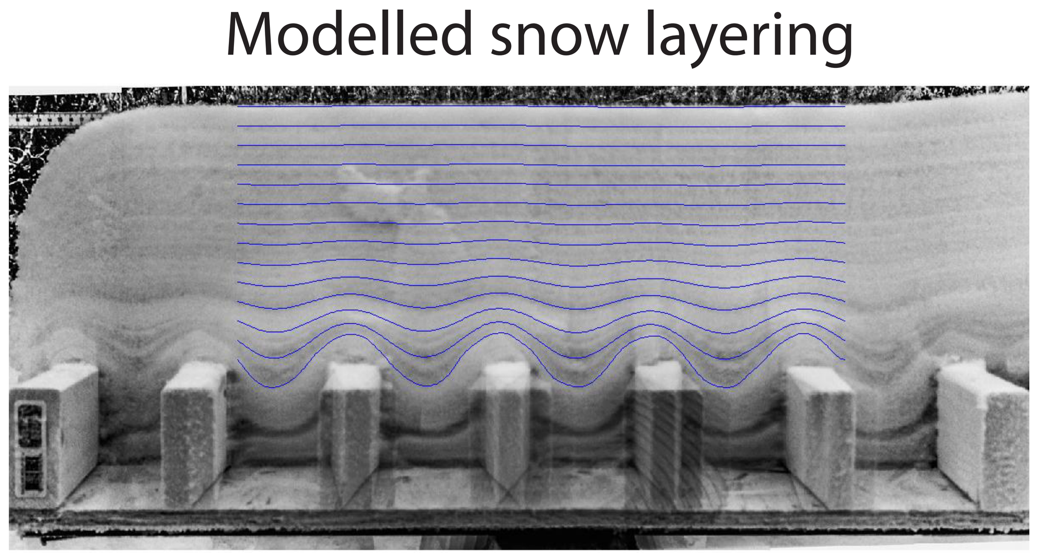


Topography & Granular behavior

Hand picked snow layering from NIR picture



Modelled snow layering

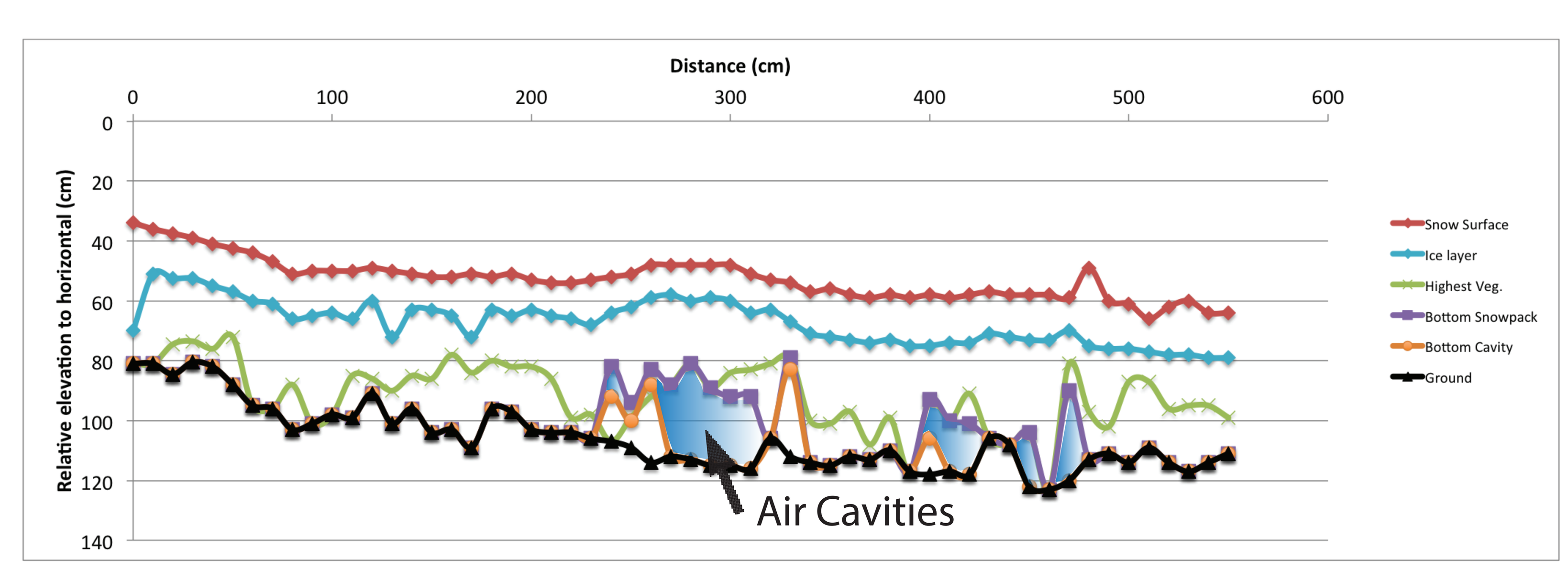


The topography and the granular behavior of snow during the accumulation phase are controling the spatial variability of snow depth in non-windy environment. Snow fills in depressions until building a continuous snow surface. Then, snow grains diffuse horizontaly leading to an eventual "flat" surface. We simulated the vertical stratigraphy of the snow pack using a 1-D diffusion equation (see figure).

$$\frac{\partial \phi}{\partial z} = k\frac{\partial^2 \phi}{\partial x^2}$$

At the snow-ground interface

At the bottom of the snowpack, plant canopies intercept snow, bend over, and form an overarching roof, preventing snow to reach the bottom of the snow pack. Air cavities in the boreal forest were less present below the snowpack in winter 2012-2013 than 2011-2012. One hypothesis lies in the weather conditions during the first snows. Warm, wet snowfall will tend to form greater volume of cavities than snow falling under cold and dry conditions. These cavities, also called the subnivean spaces by ecologists, are known to greatly influence the overwintering of the small fauna such as rodents and insects.



Acknowledgements
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